North Carolina Bicycle Crash Types
2005-2009

Prepared for

The North Carolina Department of Transportation

Division of Bicycle and Pedestrian Transportation

Prepared by

The University of North Carolina

Highway Safety Research Center

August 2011

Contents

Background

During the five year period of 2005 – 2009, an average of 965 bicycle-motor vehicle crashes were reported to the North Carolina Division of Motor Vehicles each year. On average, 23 bicyclists were killed and more than 800 were injured each year during this same period.[1]

The development of effective countermeasures to help prevent these crashes is hindered by insufficient detail on standard police report forms. The information from the crash report forms is stored on computerized files. Analysis of this data can provide information on *where* bicycle-motor vehicle crashes occur (city street, two-lane roadway, intersection location, etc.), *when* they occur (time of day, day of week, etc.), and *to whom* they occur (age of victim, gender, level of impairment, etc.), but can provide very little information about the actual sequence of events leading to the crash.

To address this situation, the National Highway Traffic Safety Administration (NHTSA) developed a system of "typing" pedestrian and bicycle crashes. Each identified crash type is defined by a specific sequence of events, and each has precipitating actions, predisposing factors, and characteristic populations and/or locations that can be targeted for interventions. The original pedestrian crash typology was developed and applied during the early 1970's (Snyder and Knoblauch, 1971; Knoblauch, 1977; Knoblauch, Moore and Schmitz, 1978). Cross and Fisher (1977) later developed a similar typology for bicycle crashes. Harkey, Mekemson, Chen, and Krull (2000) created the Pedestrian and Bicycle Crash Analysis Tool (PBCAT) that enabled both pedestrian and bicycle crash typing to be done by software. Harkey, Tsai, Thomas, and Hunter updated this tool in 2005. (See **PBCAT** for a detailed explanation of crash typing and associated crash types as well as to download the free software.) BIKESAFE provides countermeasures linked to crash type groups from PBCAT (Hunter, Thomas, and Stutts, 2006).

Example bicycle-motor vehicle crash types include:
Bicyclist ride through sign-controlled intersection,
Bicyclist left turn – same direction,
Motorist overtaking – undetected cyclist,
Motorist right-turn – same direction.

This report summarizes bicycle-motor vehicle crash types that were developed for 2005-2009 North Carolina data. UNC Highway Safety Research Center staff used PBCAT software to add a specific crash type to all bicycle-motor vehicle crashes for which a standard police report form was available. The results are summarized in the following tables and text. The crash type descriptions that follow are in part related to exposure, or when and where people ride, as well as to the types of errors made by bicyclists and drivers in maneuvers leading up to the crashes.

[1] The number of bicyclists killed and injured reflects only the "first" bicyclist reported on in the crash. A few crashes each year involve multiple bicyclists and may involve multiple injuries as well. These circumstances are, however, relatively rare, and in order not to over-represent the number of crashes, the data discussed in this report account for only the first verified bicyclist in the crash.

Results

Individual Crash Types

Table 1 shows a complete listing of all the individual crash types generated by the software coding for each of the five years and totals.

The table shows the many ways bicycle-motor vehicle collisions can occur, including various turning and merging maneuvers in traffic, overtaking events, ride outs and drive outs, bicyclists and motorists losing control of their vehicle, motorists intentionally striking bicyclists, unusual circumstances, and parking lot/non-roadway events, etc.

There is some year-to-year variability in the frequencies and proportions of each crash type, especially those with smaller numbers. Much of this variation is likely explained by chance. Starting in 2006, a new version of PBCAT has been used to type the crashes, resulting in a few changes in definitions of crash types for years since 2006 compared to 2005 and earlier years. For example, Head-On collisions were more explicitly defined to indicate which vehicle was in the wrong-lane.

Table 1. NC bicycle crash types by year.

Crash Type	2005	2006	2007	2008	2009	Total
Motorist Turning Error - Left Turn	3	6	2	7	4	22
	0.3[1]	0.6	0.2	0.7	0.5	0.5
Motorist Turning Error - Right Turn	3	2	3	1	1	10
	0.3	0.2	0.3	0.1	0.1	0.2
Motorist Turning Error - Other	1	1	0	0	1	3
	0.1	0.1	0	0	0.1	0.1
Bicyclist Turning Error - Left Turn	3	7	8	2	0	20
	0.3	0.7	0.8	0.2	0	0.4
Bicyclist Turning Error - Right Turn	5	5	2	3	0	15
	0.5	0.5	0.2	0.3	0	0.3
Bicyclist Turning Error - Other	1	0	1	0	1	3
	0.1	0	0.1	0	0.1	0.1
Bicyclist Lost Control - Mechanical Problems	5	9	9	15	7	45
	0.5	0.9	0.9	1.4	0.8	0.9
Bicyclist Lost Control - Oversteering, Improper Braking, Speed	1	4	1	3	0	9
	0.1	0.4	0.1	0.3	0	0.2
Bicylist Lost Control - Alcohol / Drug Impairment	1	5	3	1	0	10
	0.1	0.5	0.3	0.1	0	0.2
Bicyclist Lost Control - Surface Conditions	0	2	0	0	3	5
	0	0.2	0	0	0.4	0.1
Bicyclist Lost Control - Other / Unknown	6	6	6	9	11	38
	0.6	0.6	0.6	0.9	1.3	0.8

Crash Type	2005	2006	2007	2008	2009	Total
Motorist Lost Control - Mechanical Problems	0	0	1	1	0	2
	0	0	0.1	0.1	0	0
Motorist Lost Control - Oversteering, Improper Braking, Speed	1	0	0	1	1	3
	0.1	0	0	0.1	0.1	0.1
Motorist Lost Control - Alcohol / Drug Impairment	1	1	1	0	0	3
	0.1	0.1	0.1	0	0	0.1
Motorist Lost Control - Other / Unknown	1	3	2	4	6	16
	0.1	0.3	0.2	0.4	0.7	0.3
Motorist Drive Out - Sign-Controlled Intersection	77	91	79	116	81	444
	8.1	9.4	7.7	11.1	9.8	9.2
Bicyclist Ride Out - Sign-Controlled Intersection	11	22	21	22	9	85
	1.2	2.3	2	2.1	1.1	1.8
Motorist Drive Through - Sign-Controlled Intersection	1	6	2	10	5	24
	0.1	0.6	0.2	1	0.6	0.5
Bicyclist Ride Through - Sign-Controlled Intersection	83	49	75	53	36	296
	8.7	5	7.3	5.1	4.3	6.1
Multiple Threat - Sign-Controlled Intersection	n-a	0	0	1	0	1
	0	0	0	0.1	0	0
Sign-Controlled Intersection - Other / Unknown	3	7	4	17	10	41
	0.3	0.7	0.4	1.6	1.2	0.8
Motorist Drive Out - Right Turn on Red	23	21	21	18	7	90
	2.4	2.2	2	1.7	0.8	1.9
Motorist Drive Out - Signalized Intersection	2	4	3	2	9	20
	0.2	0.4	0.3	0.2	1.1	0.4
Bicyclist Ride Out - Signalized Intersection	11	19	19	3	6	58
	1.2	2	1.8	0.3	0.7	1.2
Motorist Drive Through - Signalized Intersection	0	0	3	5	7	15
	0	0	0.3	0.5	0.8	0.3
Bicyclist Ride Through - Signalized Intersection	34	28	29	22	12	125
	3.6	2.9	2.8	2.1	1.4	2.6
Bicyclist Failed to Clear - Trapped	11	5	5	8	2	31
	1.2	0.5	0.5	0.8	0.2	0.6
Bicyclist Failed to Clear - Multiple Threat	5	1	1	2	2	11
	0.5	0.1	0.1	0.2	0.2	0.2
Signalized Intersection - Other / Unknown	4	11	11	33	19	78
	0.4	1.1	1.1	3.2	2.3	1.6
Bicyclist Failed to Clear - Unknown	n-a	2	0	0	2	4
	0	0.2	0	0	0.2	0.1
Crossing Paths - Uncontrolled Intersection	11	7	0	7	8	33
	1.2	0.7	0	0.7	1	0.7

Crash Type	2005	2006	2007	2008	2009	Total
Crossing Paths - Intersection - Other / Unknown	10	18	25	2	23	78
	1.1	1.8	2.4	0.2	2.8	1.6
Motorist Left Turn - Same Direction	8	9	12	7	13	49
	0.8	0.9	1.2	0.7	1.6	1
Motorist Left Turn - Opposite Direction	56	54	58	56	53	277
	5.9	5.5	5.6	5.4	6.4	5.7
Motorist Right Turn - Same Direction	29	30	45	48	34	186
	3.1	3.1	4.4	4.6	4.1	3.9
Motorist Right Turn - Opposite Direction	8	3	8	5	7	31
	0.8	0.3	0.8	0.5	0.8	0.6
Motorist Drive In / Out - Parking	0	0	0	2	0	2
	0	0	0	0.2	0	0
Motorist Right Turn on Red - Same Direction	n-a	0	2	0	0	2
	0	0	0.2	0	0	0
Motorist Right Turn on Red - Opposite Direction	n-a	0	0	0	1	1
	0	0	0	0	0.1	0
Motorist Turn / Merge - Other / Unknown	n-a	1	2	2	1	6
	0	0.1	0.2	0.2	0.1	0.1
Bicyclist Left Turn - Same Direction	78	36	39	59	29	241
	8.2	3.7	3.8	5.7	3.5	5
Bicyclist Left Turn - Opposite Direction	11	18	14	8	3	54
	1.2	1.8	1.4	0.8	0.4	1.1
Bicyclist Right Turn - Same Direction	24	16	16	12	8	76
	2.5	1.6	1.6	1.2	1	1.6
Bicyclist Right Turn - Opposite Direction	1	0	6	3	1	11
	0.1	0	0.6	0.3	0.1	0.2
Bicyclist Ride Out - Parallel Path	8	7	6	14	5	40
	0.8	0.7	0.6	1.3	0.6	0.8
Motorist Overtaking - Undetected Bicyclist	28	33	41	38	26	166
	2.9	3.4	4	3.6	3.1	3.4
Motorist Overtaking - Misjudged Space	12	24	32	44	42	154
	1.3	2.5	3.1	4.2	5.1	3.2
Motorist Overtaking - Bicyclist Swerved	n-a	34	32	19	28	113
		3.5	3.1	1.8	3.4	2.3
Motorist Overtaking - Other / Unknown	79	68	67	75	88	377
	8.3	7	6.5	7.2	10.6	7.8
Bicyclist Overtaking - Passing on Right	1	3	2	2	4	12
	0.1	0.3	0.2	0.2	0.5	0.2
Bicyclist Overtaking - Passing on Left	0	1	2	1	0	4
	0	0.1	0.2	0.1	0	0.1
Bicyclist Overtaking - Parked	3	1	3	2	2	11

Crash Type	2005	2006	2007	2008	2009	Total
Vehicle	0.3	0.1	0.3	0.2	0.2	0.2
Bicyclist Overtaking - Extended Door	4	2	1	1	1	9
	0.4	0.2	0.1	0.1	0.1	0.2
Bicyclist Overtaking - Other / Unknown	6	4	7	6	8	31
	0.6	0.4	0.7	0.6	1	0.6
Head-On - Bicyclist	32	22	31	28	11	124
	3.4	2.3	3	2.7	1.3	2.6
Head-On - Motorist	n-a	5	9	3	2	19
		0.5	0.9	0.3	0.2	0.4
Head-On - Unknown	n-a	1	1	4	0	6
		0.1	0.1	0.4	0	0.1
Parallel Paths - Other / Unknown	14	10	10	11	11	56
	1.5	1	1	1.1	1.3	1.2
Bicyclist Ride Out - Residential Driveway	25	19	25	14	11	94
	2.6	2	2.4	1.3	1.3	1.9
Bicyclist Ride Out - Commercial Driveway / Alley	23	18	31	8	6	86
	2.4	1.8	3	0.8	0.7	1.8
Bicyclist Ride Out - Other Midblock	8	9	13	21	20	71
	0.8	0.9	1.3	2	2.4	1.5
Bicyclist Ride Out - Midblock - Unknown	38	43	32	18	26	157
	4	4.4	3.1	1.7	3.1	3.3
Motorist Drive Out - Residential Driveway	6	6	4	8	5	29
	0.6	0.6	0.4	0.8	0.6	0.6
Motorist Drive Out - Commercial Driveway / Alley	50	55	56	59	25	245
	5.3	5.7	5.4	5.7	3	5.1
Motorist Drive Out - Other Midblock	0	1	0	7	7	15
	0	0.1	0	0.7	0.8	0.3
Motorist Drive Out - Midblock - Unknown	4	1	1	3	4	13
	0.4	0.1	0.1	0.3	0.5	0.3
Multiple Threat - Midblock	n-a	6	3	5	4	18
		0.6	0.3	0.5	0.5	0.4
Crossing Paths - Midblock - Other / Unknown	5	5	1	4	2	17
	0.5	0.5	0.1	0.4	0.2	0.4
Bicycle Only	1	1	1	0	1	4
	0.1	0.1	0.1	0	0.1	0.1
Motorist Intentionally Caused	4	6	4	3	4	21
	0.4	0.6	0.4	0.3	0.5	0.4
Bicyclist Intentionally Caused	0	0	0	0	1	1
	0	0	0	0	0.1	0
Backing Vehicle	14	4	12	5	4	39
	1.5	0.4	1.2	0.5	0.5	0.8

Crash Type	2005	2006	2007	2008	2009	Total
Play Vehicle-Related	1	2	0	0	0	3
	0.1	0.2	0	0	0	0.1
Unusual Circumstances	1	2	5	3	0	11
	0.1	0.2	0.5	0.3	0	0.2
Non-Roadway	37	45	42	47	42	213
	3.9	4.6	4.1	4.5	5.1	4.4
Unknown Approach Paths	n-a	24	14	14	13	65
		2.5	1.4	1.3	1.6	1.3
Unknown Location	n-a	2	3	5	3	13
		0.2	0.3	0.5	0.4	0.3
Unknown/Insufficient Information	13	n-a	n-a	n-a	n-a	13
	1.4					0.3
Total	950	973	1030	1042	829	4824
	19.7[2]	20.2	21.4	21.6	17.2	100

[1] Row percent of the column (yearly) total
[2] Column percent of the total

To aid in comprehension, Table 2 shows the most frequent individual crash types for all five years combined. The top 11 are shown since numbers 10 and 11 are virtually tied.

Table 2. Top 11 most frequent NC bicycle crash types, 2005-2009.

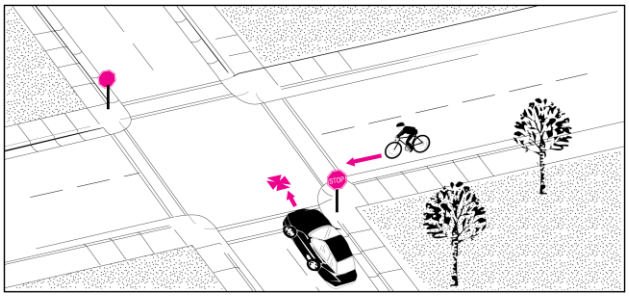
Rank	Crash Type	Total	Percent of NC Total
#1	Motorist Drive Out - Sign-Controlled Intersection	444	9.2%
#2	Motorist Overtaking - Other / Unknown	377	7.8%
#3	Bicyclist Ride Through - Sign-Controlled Intersection	296	6.1%
#4	Motorist Left Turn - Opposite Direction	277	5.7%
#5	Motorist Drive Out - Commercial Driveway / Alley	245	5.1%
#6	Bicyclist Left Turn - Same Direction	241	5.0%
#7	Non-Roadway	213	4.4%
#8	Motorist Right Turn - Same Direction	186	3.9%
#9	Motorist Overtaking - Undetected Bicyclist	166	3.4%
#10	Bicyclist Ride Out - Midblock - Unknown	157	3.3%
#11	Motorist Overtaking - Misjudged Space	154	3.2%
	Total for top 11 crash types	2756	57.1%

These 11 crash types accounted for 57% of the State total bicycle-motor vehicle crashes. Parallel path types of crashes (rank #s 2, 4, 6, 8, 9, 11) – that is, ones in which the motorist and

bicyclist were initially on parallel paths before any turns or other maneuvers that led to the crash – accounted for 29% of the total over this time period. Crossing path crashes (rank #s 1, 3, 5, and 10) – that is ones in which the motorist and bicyclist were initially on crossing or perpendicular paths – accounted for 24%. Non-roadway types of crashes such as in parking lots or on public or private driveways accounted for another 4%.

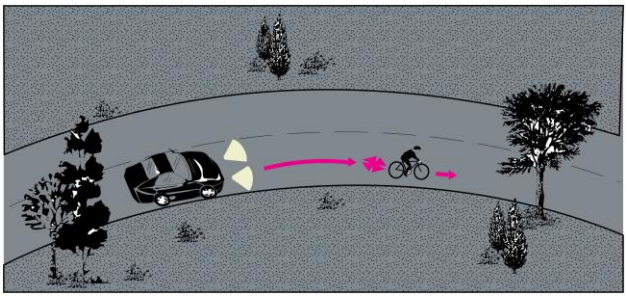
Educational messages and training could focus on the most common types of errors and situations that lead to the most common types of collisions. For further targeting countermeasures, adults and children also tend to be involved in different types of collisions at different locations. Often both driver and cyclist contributed to the crash. Education and enforcement efforts should target safe driving around bicyclists and reinforce both motorists and bicyclists following traffic laws. Both children and adults should be encouraged to properly use safety helmets when riding to help prevent injuries in crashes. Helmet use is required by law Statewide for children 15 and younger when riding on public thoroughfares. Children should also be closely supervised, provided safe places to ride and to learn safe cycling, and taught about hazards when riding on sidewalks and neighborhood streets as they mature enough to ride in these locations.

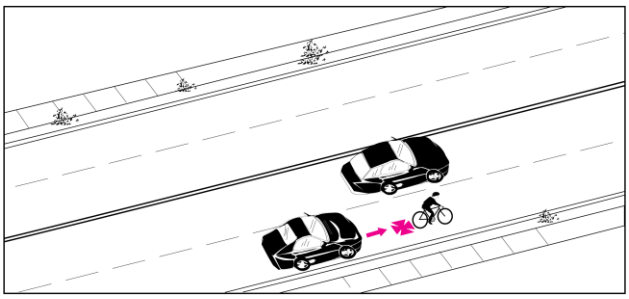
The most frequent event coded over this time period, **Motorist Drive Out – Sign-Controlled Intersection** refers to a motorist who apparently obeyed a stop sign but then drove out into the path of the bicyclist. In 59% of the NC crashes of this type, bicyclists were riding wrong-way (facing traffic, whether on the sidewalk or the roadway) and therefore may have contributed to the crash by coming from the motorist's right where the motorist was less likely to expect or notice them before pulling out.



Motorist Overtaking – Other/Unknown, the second most frequent crash type, describes events where the motorist and bicycle were on parallel paths in the same direction and there was no information to indicate whether the motorist misjudged the space needed to pass, failed to detect the bicyclist, or the bicyclist swerved into the path of the motorist.

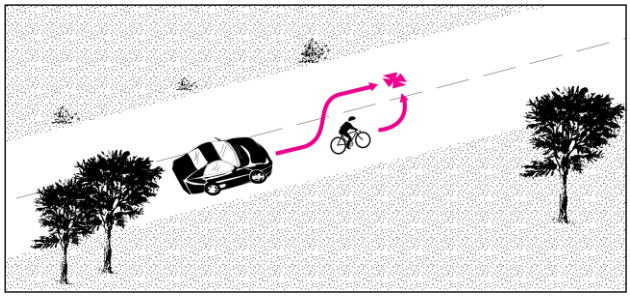
There are three other types of **Motorist Overtaking** crash types; two others are in the top 11 list: **- Undetected Bicyclist** is a relatively frequent occurrence and is 9th in the list above.



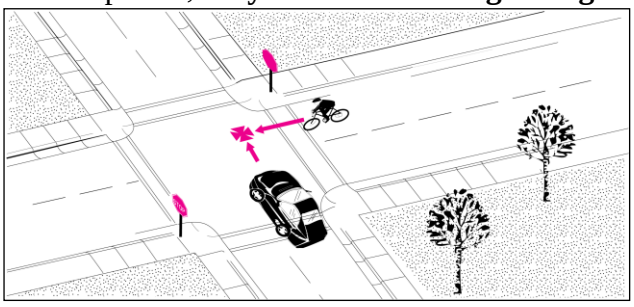


Motorist Overtaking - Misjudged Space, 11th in rank order, describes cases where the motorist apparently misjudged the space or distance needed to pass.

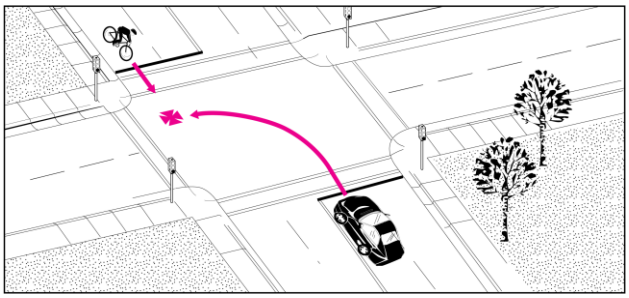
Although not in the top 11, **Motorist Overtaking – Bicyclist Swerved** describes cases where the bicyclist suddenly swerved (apparently not an intentional merge or turn) into the path of the overtaking motorist. This type also accounted for a significant number of all bicycle-motor vehicle crashes, even though this specific type has only been coded since 2006.

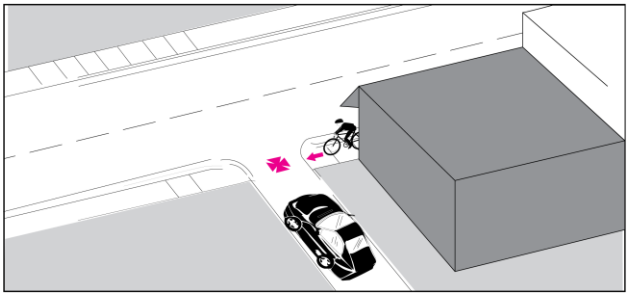


The third most frequent collision type over this time period, **Bicyclist Ride Through – Sign-Controlled Intersection**, is typically an event where the bicyclist ignored the sign controlling the bicyclist's direction. A lack of on-road bicycling experience, failure to notice the sign or look for conflicting traffic, or a reluctance to lose momentum and a misjudgment of the available gap are factors that could be present in such a crash type.



Motorist Left Turn – Opposite Direction (#4) involves events where the motorist turns left at an intersection or driveway in front of an oncoming bicyclist.

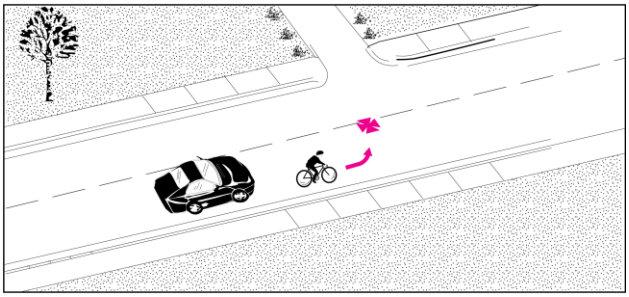




Motorist Drive Out - Commercial Driveways (#5) involves motorists driving out at these locations and failing to yield right-of-way to approaching bicyclists. As is also the case with motorist drive outs at sign-controlled junctions, this type has an over-representation (72% of the cases) of bicyclists traveling from the motorist's right against

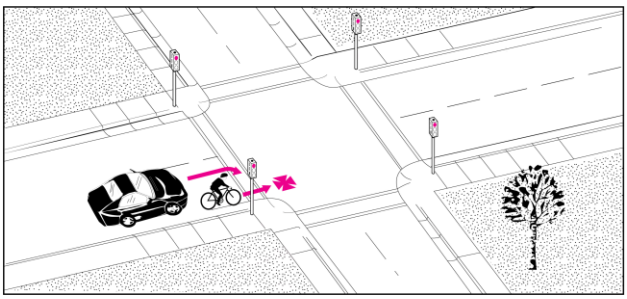
traffic (wrong side of street).

Bicyclist left turn – Same Direction (#6) involves a bicyclist traveling in the same direction as a motor vehicle and turning or merging left in front of, or into the side of, the motor vehicle traveling in the same direction.



The 7th most frequent crash type is a catch-all category for all **Non-Roadway** collisions that were reported (image not shown). This type means the crash occurred off the roadway network and typically refers to parking lot crashes but may also include crashes on public and private driveways and other off-roadway areas.

Eighth on the list, **Motorist Right Turn – Same Direction** involves motorists passing and turning right (sometimes known as the "right-hook") in front of bicyclists who were traveling along the same roadway (or an adjacent path or walkway) in the same direction.



Bicyclist Ride Out –Midblock - Unknown (#10) involves bicyclists riding out and into the path of a motor vehicle from midblock locations not clearly known to be commercial or private driveways (not shown). This type may include ride-outs from yards or other areas adjacent to roadways.

For complete crash type definitions, see PBCAT Manual and Tech Support**,** Appendix C. Example crash type images are also available on the PBCAT web pages.

Crash Location

Table 3 shows the frequency and percentage of bicycle crashes by the general crash location. Nearly half (49%) of the collisions occurred in non-intersection (i.e., mid-block) locations along streets and roadways. Another 44% were in the intersection (i.e., within the motor vehicle stop bars or pedestrian crosswalks), and 3% were intersection-related (i.e., close enough that an intersection maneuver such as slowing traffic may have led to the crash). About 5% occurred in non-roadway locations (typically parking lots).

Table 3. NC bicycle-motor vehicle crashes by location type.

Crash Location	2005	2006	2007	2008	2009	Total
Intersection	419	436	431	461	350	2097
	44.[11]	44.8	41.8	44.2	42.2	43.5
Intersection-Related	7	20	35	28	32	122
	0.7	2.1	3.4	2.7	3.9	2.5
Non-Intersection	478	470	519	501	402	2370
	50.3	48.3	50.4	48.1	48.5	49.1
Non-Roadway	45	45	42	47	42	221
	4.7	4.6	4.1	4.5	5.1	4.6
Unknown Location	1	2	3	5	3	14
	0.1	0.2	0.3	0.5	0.4	0.3
Total	950	973	1030	1042	829	4824
	19.7[2]	20.2	21.4	21.6	17.2	100

[1] Row percent of column total
[2] Column percent of row total

Figure 1 shows how the proportion of location types vary from rural to urban crash locations in NC, and may also vary from city to city, depending on how closely-spaced intersections are, and other factors. Non-intersection crash locations make up an even higher percentage, 70%, of the total bicycle crashes in rural areas compared with 40% in urban areas, while non-roadway (parking lot crashes) are understandably a lower percentage (<3%) in rural areas than in urban (6%).

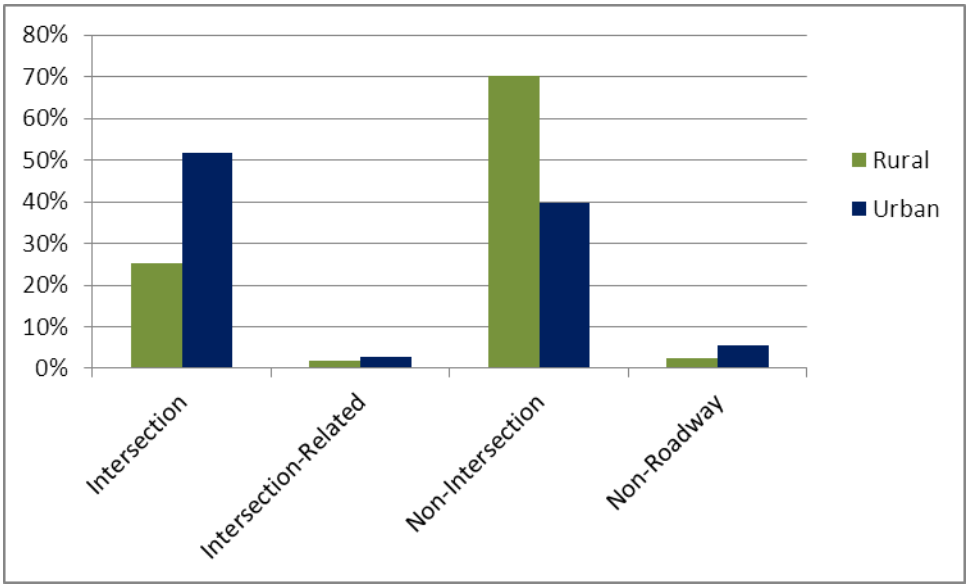


Figure 1. NC rural and urban bicycle crash percentages by location type, 2005-2009.

In addition to greater numbers of crashes, the fatality rate for bicyclists struck along road sections (non-intersection or midblock locations) is considerably higher than that at intersection locations. Fatal crashes as a percentage of the total at midblock locations were 3.4 times higher than that for collisions at intersections. The 88 fatal crashes at midblock locations represent 77% of all fatal bicycle-motor vehicle crashes, with 22% of fatal crashes occurring at intersection and intersection-related locations (Figure 2). Only one fatal bicycle crash was *reported* from non-roadway locations. In part, these findings reflect bicyclists being struck at a higher rate at non-intersection locations in rural areas, where speeds are typically higher, roadways are often not lighted, and other factors.

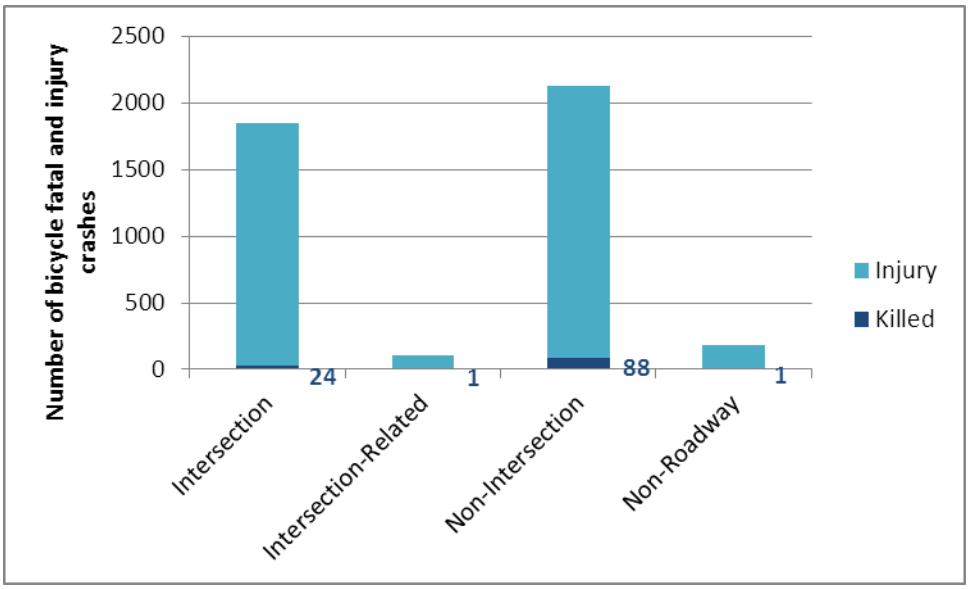


Figure 2. NC fatal and injury crash numbers by location type, 2005-2009.

Bicyclist Position

Table 4 shows the initial position of the (primary) bicyclist involved the crash and indicates that 62% of the bicyclists were on a street in a lane shared with motor vehicle traffic just prior to the crash. On average, another 14% were on a sidewalk, crosswalk, or crossing a driveway just prior to the collision. About 4% were on a driveway or alley before any maneuvers such as the bicyclist riding out into a street, or a motor vehicle turning in, and another 6% were in other non-roadway areas such as parking lots. Bicyclists were riding on paved shoulders or bicycle lanes about 5% of the time prior to their collisions on average. Bicyclist initial position was unknown/unable to be determined in an average of 8% of the crashes.

Table 4. Bicyclist position prior to the crash, NC bicycle-motor vehicle crashes.

Bicyclist Position	2005	2006	2007	2008	2009	Total
Unknown	106	98	95	61	47	407
	11.2[1]	10.1	9.2	5.9	5.7	8.4
Travel Lane	578	599	640	635	547	2999
	60.8	61.6	62.1	60.9	66	62.2
Bike Lane / Paved Shoulder	45	33	43	71	37	229
	4.7	3.4	4.2	6.8	4.5	4.7
Sidewalk / Crosswalk / Driveway Crossing	113	137	127	179	124	680
	11.9	14.1	12.3	17.2	15	14.1
Multi-use Path	8	5	8	7	3	31
	0.8	0.5	0.8	0.7	0.4	0.6
Driveway / Alley	47	42	53	18	16	176
	4.9	4.3	5.1	1.7	1.9	3.6
Non-Roadway	48	56	58	63	50	275
	5.1	5.8	5.6	6	6	5.7
Other	5	3	6	8	5	27
	0.5	0.3	0.6	0.8	0.6	0.6
Total	950	973	1030	1042	829	4824
	19.7[2]	20.2	21.4	21.6	17.2	100

[1] Row percent of the column (yearly) total
[2] Column percent of the total

Bicyclist Direction of Travel

Table 5 shows that 55% of the bicyclists were riding with traffic (i.e., in the same direction as traffic) and 24% were riding opposed or facing traffic. (The percentage riding opposed to traffic was 30% when including only crashes on the roadway network for which direction was known.) Direction was considered not applicable for parking lot, driveway, and other off-road locations. Bicyclist travel direction was unknown/not determinable for about 10% of the crashes.

Riding facing traffic is against the rules of the road and may contribute to crash occurrence since bicyclists are approaching from an unexpected direction.

Table 5. Bicyclist direction in NC bicycle-motor vehicle crashes.

Bicyclist Direction	2005	2006	2007	2008	2009	Total
Unknown	111	154	133	44	28	470
	11.7[1]	15.8	12.9	4.2	3.4	9.7
With Traffic	488	470	556	628	503	2645
	51.4	48.3	54	60.3	60.7	54.8
Facing Traffic	244	257	232	252	175	1160
	25.7	26.4	22.5	24.2	21.1	24
Not Applicable	107	92	109	118	123	549
	11.3	9.5	10.6	11.3	14.8	11.4
Total	950	973	1030	1042	829	4824
	19.7[2]	20.2	21.4	21.6	17.2	100

[1] Row percent of column total
[2] Column percent of row total

Grouped Crash Types

For ease in understanding, the individual crash types from Table 1 have been consolidated into fewer (21) related crash type groups for additional examination and analyses. For example, the four separate **Motorist Overtaking** crash types in Table 1 are combined as one crash type group. These combined crash groups also show some variability by year but less than the individual crash types. Examining the totals across all five years, crash type groups are shown in rank order of frequency (Table 6).

Table 6. NC bicycle-motor vehicle crash type groups, 2005-2009.

Rank	Grouped Bicyclist Crash Type	Total	Percent of NC Total
#1	Motorist Overtaking Bicyclist	810	16.8%
#2	Motorist Failed to Yield - Sign-Controlled Intersection	468	9.7%
#3	Bicyclist Failed to Yield - Midblock	426	8.8%
#4	Bicyclist Failed to Yield - Sign-Controlled Intersection	382	7.9%
#5	Motorist Left Turn / Merge	326	6.8%
#6	Motorist Failed to Yield - Midblock	302	6.3%
#7	Bicyclist Left Turn / Merge	295	6.1%
#8	Crossing Paths - Other Circumstances	247	5.1%
#9	Bicyclist Failed to Yield - Signalized Intersection	229	4.7%
#10	Motorist Right Turn / Merge	220	4.6%
#11	Non-Roadway	213	4.4%
#12	Loss of Control / Turning Error	204	4.2%
#13	Head-On	149	3.1%
#14	Motorist Failed to Yield - Signalized Intersection	125	2.6%
#15	Parallel Paths - Other Circumstances	102	2.1%
#16	Other / Unknown - Insufficient Details	91	1.9%
#17	Bicyclist Right Turn / Merge	87	1.8%
#18	Bicyclist Overtaking Motorist	67	1.4%
#19	Other / Unusual Circumstances	40	0.8%
#20	Backing Vehicle	39	0.8%
#21	Parking / Bus-Related	2	0.0%
	Total	4824	100.0%

The top 12 groups accounted for 85% of the State's reported bicycle collisions. The names of the groups are reasonably self-explanatory.

The most frequent group, **Motorist Overtaking Bicyclist,** accounted for 17% of the collisions Statewide and describes all situations in which the motorist was approaching a bicyclist from behind and a collision occurred when the motorist was overtaking or attempting to pass the bicyclist. These collisions may be reduced by measures to provide separate space for bicyclists to ride on the roadway (as opposed to shared lanes), educating bicyclists to always use lights at night, and enforcing laws relating to safe overtaking.

Motorist Failed to Yield - Sign-Controlled Intersection (#2) indicates that the motorist either failed to stop or stopped and then drove out into the path of a bicyclist crossing the intersection. This type accounted for about 10% of all the collisions statewide. As mentioned before, bicyclist wrong-way riding may contribute to these types of crashes. Bicyclists may ride on sidewalks, where they more often ride wrong-way, when they don't feel comfortable with the speed and volume of traffic on the roadway. Thus, conditions should be assessed to ensure that "Complete Streets" facilities are appropriate for all users for the volume and traffic, number of travel lanes, and other roadway factors present. Enforcement of yielding laws, bicycle lighting laws, ensuring intersections have adequate sight distance, narrowing curb radii, and other measures may also help ensure that motorists yield before driving out or turning right without yielding to bikes.

Bicyclist Failed to Yield - Midblock (#3) describes all the situations in which a bicyclist rode out from a non-intersection location such as a commercial or private driveway or yard and into the path of a motorist on the roadway. This group accounted for nearly 9% of crashes. Countermeasures include ensuring that sight distance/visibility is clear around driveways (including parked cars); educating bicyclists, especially child bicyclists, on looking behaviors and not riding out from between parked vehicles or other obstacles; and ensuring that speeds are appropriate to the roadway and uses. Bicyclists have difficulty detecting a safe gap if travel speeds are too high.

Bicyclist Failed to Yield - Sign-Controlled Intersection (#4) is similar to #3, except in this case, the bicyclist either rode through a stop sign without stopping or stopped and then rode into the path of a motorist. This group comprised about 8% of all the crashes. Bicycle boulevards might be created in areas with a large number of cyclists to create a route that favors bicycle travel and to reduce the number of stops cyclists have to make. Educational measures may also be taken, and again, traffic speeds and gaps in traffic are important factors.

Motorist Left Turn/Merge (#5) describes situations in which a motorist turned or merged into the path of a bicyclist who was either traveling from the opposite or same direction parallel to the motorists' path. This type may also include driving in or out of parking spaces or bus or delivery vehicle pullovers, and as a group, accounted for about 7% of crashes. Protected left turns at signalized locations, enforcement, ensuring bicyclists use lights at night, and educational measures may help to reduce these types.

Motorist Failed to Yield – Midblock (#6) describes situations where the motorist drove out from commercial or residential driveways or other midblock locations and into the path of a bicyclist traveling along the roadway (including adjacent sidewalks or paths). This type accounted for about 6% of the crashes. Bicyclist education about wrong-way riding and motorist education and enforcement of traffic yielding laws are remedies to consider along with potential engineering remedies.

Bicyclist Left Turn/Merge (#7 on the list) includes bicyclists turning or merging left into the path of motor vehicles traveling in the same or opposite direction and accounted for about 6% of crashes, and has dropped in rank in recent years. This type also includes bicyclists riding along a parallel walkway or sidepath who rode out into the roadway in a parallel direction to (not across) traffic. Potential remedies include bicyclist education and slowing vehicle speeds (so

that bicyclists have time to merge across lanes). Engineering measures at intersections may also help.

Crossing Paths - Other Circumstances (#8) describes situations in which bicyclists and motorists were on perpendicular paths at intersections or midblock locations prior to the crash, but traffic control or right-of-way or other details are unknown or do not fit any of the other situations described. Since details are lacking, countermeasures are difficult to identify.

Bicyclist Failed to Yield - Signalized Intersection (#9 on the list with 5%) is similar to # 4 on the list, except here the bicyclist either rode through a red light or stopped and then rode into the intersection and into the path of a motor vehicle against a signal indication. This group includes instances in which the bicyclist may not have been detected for a signal change, may have been trapped by a signal change or otherwise failed to clear the intersection on a changing signal in the time allowed or before vehicles began moving, bicyclist errors, or intentional violations. Countermeasures would include ensuring bicyclists are detected at signalized locations, that timing allows for sufficient bicyclist clearance intervals, other possible intersection safety improvements, as well as educational/training measures.

Motorist Right Turn / Merge (#10, also about 5% of crashes) describes all situations in which the motorist turned right across the path of a through bicyclist – typically in the same direction, but sometimes with bicyclists traveling from the opposite directions (and perhaps wrong-way). Bicycle boxes or advance stop bars that allow bicyclists to proceed to the front of a queue on a red signal when bike lanes or other space is available, may help reduce this type of crash when it involves vehicles turning right from a stopped position. Other remedies include enforcement of appropriate traffic laws and motorist and bicyclist education.

Non-roadway (#11) means the crash occurred off the roadway such as in a parking lot or private driveway. All non-roadway crashes accounted for about 4%.

Finally, **Loss of Control / Turning Error** types of crashes (#12, 4%) describes situations in which either the motorist or the bicyclist turned into the wrong lane or cut the corner, or otherwise lost control during the turn. These crashes typically result from too-high turning speed. Reducing curb radii, adding median dividers at intersections, and providing protected lefts at signalized locations are potential remedies.

The remaining crash type groups together accounted for less than 15% of the total, but crash countermeasures may still be available for some. More information on potential countermeasures for all of the above types of crashes may be reviewed in the interactive Web site and document, BIKESAFE: Bicycle Countermeasure Selection System (BIKESAFE), and in other information and links to additional resources contained on the Pedestrian and Bicycle Information clearinghouse sites (PBIC) developed for the U.S Department of Transportation, Federal Highway Administration. In order to develop countermeasures for particular locations, crash data specific to those locations would need to be examined. A comprehensive evaluation through on-site safety audits, including behavioral and engineering evaluations would also be needed.

Injury Severity and Crash Types

Some types of crashes have also resulted in fatal and severe injuries more frequently than others. Examining the crash type groups by the **injury severity** of the bicyclist (data not shown) reveals the following:

- Bicyclists were more likely to be killed or seriously injured in **Head-On** and **Motorist Overtaking** collisions, and to a lesser extent when **Bicyclists Failed to Yield at Sign-Controlled Intersections** just before their crash.
- The highest percentage and the most fatalities occurred in **Motorist Overtaking** crashes. About 17% of all crashes involved motorists overtaking bicyclists, but 39% of the fatal crashes and 23% of serious (disabling type) injuries resulted from this type of crash.
- **Head-On** collisions represented a little more than 3% of crashes, but 11% of fatalities (12 total) and 6% of serious injuries.
- **Bicyclists Failied to Yield at Sign-Controlled Intersections** represented 8% of crashes and was slightly over-represented with 10% of fatalities, and than 15% of serious (disabling) injuries.

Note that injury severity results from a combination of factors including speed, closing-speed, and detection and braking/taking avoidance action, each of which may be influenced by conditions such as the where the crash took place, ambient and supplemental lighting, direction the cyclist was riding, and others.

An examination of the direction or riding by age of the bicyclist showed that riders of all ages were involved in collisions where the rider was riding in the wrong direction,; however, bicyclists of ages 16 – 19 and 25 – 29 were most likely to be riding wrong-way in their crashes, compared with other age groups.

For more information on bicycle crashes including characteristics of bicyclists and drivers involved, and descriptions of environmental, roadway, and other factors present, see the NC **Bicycle Crash Facts** summary report.

References

Cross, K.D. and Fisher, D. (1977). A study of bicycle / motor vehicle accidents: identification of problem types and countermeasure approaches. Santa Barbara, California: Anacapa Sciences, Inc. [DOT HS-803-315]

Harkey, D.L., Mekemson, J., Chen, M-C., and Krull, K. (2000). Pedestrian and Bicycle Crash Analysis Tool (PBCAT) User's Manual. McLean, Virginia: Office of Safety Research and Development, Federal Highway Administration. [FHWA-RD-99-192]

Harkey, D.L., Tsai, S., Thomas, L., and Hunter, W.W (2006). Pedestrian and Bicycle Crash Analysis Tool (PBCAT): Version 2.0 Application Manual, Federal Highway Administration, Office of Safety Research and Development: McLean, VA, 241 pp. [FHWA-HRT-06-089, document and software available at: http://www.walkinginfo.org/facts/pbcat/about.cfm]

Hunter, W.W., L. Thomas, and J.C. Stutts (January 2006). BIKESAFE: Bicycle Countermeasure Selection System. Federal Highway Administration, Office of Safety Programs: Washington, D.C. [FHWA-SA-05-006; Web site: http://www.bicyclinginfo.org/bikesafe/index.cfm]

Knoblauch, R.L. (1977). Causative factors and countermeasures for rural and suburban pedestrian accidents: accident data collection and analysis. Falls Church, Virginia: BioTechnology, Inc. [DOT HS-802-266]

Knoblauch, R.L., Moore, W., and Schmitz, P.R. (1978). Pedestrian accidents occurring on freeways: an investigation of causative factors, accident data collection, and analysis. Washington, DC: Federal Highway Administration. [FHWA RD-78-169/171]

National Highway Traffic Safety Administration (n.d.). Manual accident typing for pedestrian accidents: coder's handbook. Washington, DC: National Highway Traffic Safety Administration.

Snyder, M.B. and Knoblauch, R.L. (1971). Pedestrian safety: the identification of precipitating factors and possible countermeasures. Vol. I and II – Appendices. Silver Spring, Maryland: Operations Research, Inc. [DOT/ NHTSA. FH-11-7312]